EPSRC & SFI Centre for Doctoral Training in Advanced Metallic Systems

PhD in Thermo mechanical effects on Ti deformation mechanisms in cold dwell.

Supervisors: Prof João Fonseca & Prof Phillip Withers
Collaborator: Rolls Royce
Based at: The University of Manchester
Stipend: UKRI stipend (£15,609 in 2021-22) plus £3,250 per year, for an eligible student
Open to: Candidates with a strong degree in a STEM discipline .

The Centre for Doctoral Training in Advanced Metallic Systems is a partnership between industry partners and the Universities of Sheffield and Manchester and the I-Form Advanced Manufacturing Centre, Dublin. CDT students undertake a doctorate with an in-depth technical and professional skills training across a structured 4-year programme. For more information on our cohort training programme and our impact from our doctoral research projects with industry please visit www.metallicscdt.co.uk. This project is based at the University of Manchester and is sponsored by Rolls Royce. It is open to candidates with a strong degree in a STEM discipline. Experience using computers to analyse and solve problems using Python and/or Matlab would be beneficial.

Titanium alloys are used in high performance rotating components in the aerospace industry, particularly compressor discs, as they possess high strength/weight ratios and excellent fatigue and corrosion re-sistance. Titanium alloy products are generally forged and machined, and over recent years, the machin-ing force feedback response has been used to provide an indication of grain structure in forged material and the influence of upstream forging on texture development.

Titanium alloys are used extensively in the manufacture of aero-engine components, owing to their high strength and relatively low density. These alloys owe their exceptional properties to their structure at the microscopic scale, the microstructure, which can be controlled during alloy processing and component manufacture. Viewed through a microscope, these alloys can be seen to contain inter-penetrating crystals, of sizes ranging from a few manometers to several micrometers, which ultimately control the properties of the material. One of the most important properties of these alloys is their resistance to fatigue failure, that is, failure after repeated loading cycles, where the stress in the material is well below its ultimate strength. Although the stresses are very low, some of the crystals making up the alloy can deform and eventually introduce damage and eventually failure. Cyclic loading is characteristic of components in an aero-engines, where they are exposed to both low frequency (e.g. take off and landing), and high frequency (e.g vibration) loading. Therefore it is very important to understand what gives Ti alloys their fatigue strength, and in particular how it is affected by the load frequency and by other environmental parameters like temperature.

Through extensive testing, engineers have developed sound empirical relationships between fatigue strength and the microstructure of different Ti alloys. However, the actual physical mechanisms controlling this behaviour are not fully understood. This gap in our knowledge makes it difficult to account for material and/or operating conditions outside previous experience. It also makes it difficult to understand how the alloy could be improved, so that less of it can be used, which would help build lighter, more efficient aero-engines.

The aim of this project is to improve our understanding of how these important alloys deform at the micro-structural scale during low frequency cyclic loading, and at different temperatures. Working in collaboration with Rolls-Royce, you will use new experimental techniques developed at the University of Manchester to measure the deformation of these alloys with sub-micron spatial resolution, helping to unravel the physical process that lead to fatigue failure and damage and understand how they can be avoided. This work will make use of unique state-of-the-art facilities available at the Royce Institute at Manchester (www.royce.ac.uk), including high-resolution electron microscopes with in-situ testing capability, machines for 3-dimensional crystal orientation mapping, and high resolution transmission electron microscopes.

The successful candidate will join a large team of researchers (10+) working on titanium alloys at Manchester, and collaborate with scientists and engineers at Rolls-Royce and other UK and international universities. The project provides access and training on some of the most advanced characterisations methods currently available and sound training in advanced data analysis using open source packages. There will also be opportunities to visit Rolls-Royce and other partner organisations.

For more information please contact Prof João Fonseca (joao.fonseca@manchester.ac.uk)

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